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Research Article

Awareness towards Efficiency of Green and Conventional Building Materials used in Pakistan

Sadia Farooq[1*], and Isma Yaqoob[2]

[1]Department of Family and Consumer Science, University of Home Economics, Lahore, Pakistan
[2]Department of Housing, Home Management and Interior Design, Govt. College of Home Economics, Lahore, Pakistan

Abstract: All over the world; including Pakistan, there is a great deal of emphasis being placed on the need for 'green' structures which are efficient with minimum negative impact during construction as well as during their life-cycle, and have a positive impact on climate and surrounding environment. This study reveals an effort to investigate the efficiency of green building materials available in local markets. It also aims to analyze the awareness levels of different people with respect to green building materials. A comparison of cost of green and conventional building materials is given, the materials are delimited only to wall and ceiling. An analysis of a house constructed using green building materials is also part of the study. The study uses mixed method research; a questionnaire is used for testing the awareness level of people. Results conclude that architects know the benefits of green building materials but contractors and building residents must be guided about advantages of materials. Materials like a green roof, insulation, low Emissivity (E) windows and low volatile organic compound (VOC) paints are more energy efficient than conventional ones. Cool brick and fly ash brick are discussed as upcoming green materials in Pakistan. The study shows that going green costs more than conventional materials but there are long term benefits for the society at large, thereby giving them the incentive to adopt green building materials. The study opens the new horizon in front of scholars to give way to the professionals and laypersons to opt for green building materials.

Keywords: Green Buildings, Green Materials, Sustainability, Conventional, Efficiency.

1. INTRODUCTION

"We shape our dwellings, and afterward our dwellings shape our lives" [1] are words by none other than Winston Churchill. The world is changing day by day and our survival is getting difficult in this situation. One reason for the social, financial and atmospheric crisis is depletion of nature's bounty. The danger of disappearing purity and excellence of the world by the most exceedingly terrible utilization of accessible assets has also served as an influencing factor. The modern era is the era of construction and buildings which is possible because of the available natural resources [2]. Milani defined green materials in his book "Designing the Green Economy" as:" A green material is one that simultaneously does the most with the least, fits most harmoniously within ecosystem processes, helps eliminate the use of other materials and energy, and contributes to the attainment of a service-based economy" [3]. But a conventional building material is the ordinary material which is being used everywhere such as a simple brick roof, windows, walls, etc.

Green building refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition. This requires close cooperation of the contractor, the architects, the engineers, and the client at all project stages [4]. Green building concept actually refers to a process that

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*Corresponding Author: Sadia Farooq <drsadiafarooq@gmail.com>

is environmentally responsible and resource-efficient throughout the building's life-cycle. The process has applicability in all distinct phases of the building life cycle which includes design, construction, operation, maintenance, renovation, and demolition. The energy crisis, water shortage, poor waste management, and less intelligence [5].

Spiegel and Meadows in their book "Green Building Materials: A Guide to Product Selection and Specification" state that to distinguish between green and non-green materials lies within five questions that are hazardous, local, recycled, energy-efficient and reusable or recyclable [6].

Architects and environmentalists around the world are going for green architecture in order to reserve world's resources. United States Green Building Council (USGBC) formed in 1993 was the first council to work for green buildings defines green materials as the materials that focus on three main areas such as the materials that emphasis on three principle regions, for example, protection of materials, ecologically ideal materials, squander the board and decrease waste management and reduction [4, 5, 7].

Leadership in Energy and Environmental Design (LEED) is a building certification developed by United States green building council (U.S.G.B.C), it assesses a lot of rating framework for the structure, development, activity, and support of green buildings, homes, and neighborhoods. LEED rating provides a basis to identify the degree of resource efficiency of the project. LEED certification has four levels which are certified, silver, gold, and platinum with points respectively 40–49, 50-59, 60-79, 80 and above [7].

Zhang et al. (2019) conducted a research to compare the development status of green buildings in various countries with an overall green building development situation within these countries, summarizing with economic benefits how users interact with the Green building technology to correctly understand and use green building technology and to strengthen technology innovation [8]. Hwang and Tan (2012) searched that Singapore also has a barrier in going towards green construction which is high cost [9]. The Indian scholars like, Goel, Ganesh & Kaur (2019) also afforded to highlight the need for a comprehensive assessment of green development in which they also compared their country with other developed countries [10]. India is also struggling for a fruitful development for green structure and their point is to turn into the pioneer of supportable design till 2025 [10]. Pakistan additionally needs to take activities in the structure division to have its influence on rationing assets. The impact of indoor temperature under both conventional and green roof showed a significant reduction in indoor temperature peaks in comparison to ambient temperature. The maximum difference between ambient and green roof surface temperature was 11^{o}C, similarly, considerable reduction in green roof surface temperature was observed as compared to traditional roof surface [11]. Some results from past studies concluded that construction industry has indeed called for analysis which could give deeper insights about the challenges and problems currently prevailing and creating hurdles in adopting and implementing green building technology in Pakistan [5]. Pakistan also has an active organization for promoting green development, named, Pakistan Green Building Council (PGBC) with a mission to enhance environmental performance and human health benefits and to expand industries to enable sustainability at all levels. It is working with Government and international organizations, developing and conducting many courses and organizing conferences to aware people of green growth. They also provide guidance to follow LEED certification guidelines in construction of buildings surface [12].

Vitality lack in Pakistan can be overwhelmed by numerous techniques by lowering the consumption of materials in buildings or to alter conventional building materials with green ones. A lot of cash can be spared to manage the pervasive vitality emergency by structure houses and structures that are green. Such structures would preserve a great deal of vitality that is ordinarily squandered in standard abodes. There are various advantages to develop green structure, including natural, monetary, and social remuneration. The study will also help to facilitate contractors and builders in building sector of Pakistan about the available options for going for green architecture [5]. The previous studies also showed that a green building

uses less energy, lower maintenance costs, higher occupant satisfaction and less greenhouse gas emissions in comparison of an average conventional building [5, 6, 11]. The study is conducted to reduce the deficiency in awareness and promotion of local market of green building materials, finally to raise the demands for green materials in market. As a developing country, Pakistan must sustain its level at least with the Asian countries. The objectives of the study are as followings:

- To analyze the awareness level of architects, contractors and building residents about green building materials.
- To investigate the efficiency of green building materials available in local markets.
- To compare the cost of conventional and green building materials.

To analyze a residential building having LEED certification.

2. RESEARCH METHODS

A mixed-method research is conducted and presented about the use and efficiency of available materials which can contribute to the green buildings. The research was categorized into three sections.

Section 1 includes a survey conducted to find out the awareness level of architects, contractors and building residents about the differences in green and conventional building materials. The questionnaire was prepared on ten statements, developed with the help of an article by Emily Rabin (2005) [13]. The questionnaire used a Likert scale ranging from (1-5), 1 strongly disagree, 2 disagree, 3 agree to some extent, 4 agree and 5 strongly agree. Section 2 includes a market survey for the comparison of cost of green and conventional building materials along with the differences between green and conventional building materials, collected from the previous researches. Section 3 includes a description of a green residential building.

2.1 Sample

2.1.1 Section 1

The sample was the architects and contractors who were involved in building construction and building residents of Lahore, Pakistan, who were living in different localities, the residents were selected on the bases of literacy as all residents were postgraduate and working in government sector. A total of 18 architects, 22 contractors and 41 building residents participated in the study who filled the questionnaire accurately.

2.1.2 Section 2

This section investigates the green building materials available in local markets and to compare the cost of conventional and green building materials as stated in objective 2 and 3. The three markets were selected for survey, named as Beadon road market, Township market and Ferozepur road market, total of 60 shops were selected. The building materials were delimited only to two interior elements, one wall and second ceiling such as insulation, Low Emissivity (E) window, Low volatile organic compound (VOC) paints for wall and green roof for ceiling. The materials for the floor were excluded from the study.

2.1.3 Section 3

A residential building was selected which was planned on basis of LEED Gold certification accordingly the completed project attains LEED points between 60 and 79 from its four levels [7].

3. RESULTS AND DISCUSSION

3.1 Awareness Level of Architects, Contractors, and Building Residents (Section 1)

The following statements were answered by the architects, contractors and building residents which showed their awareness level in Table 1.

The results in Table 1 shows that the mean ranges from 2.31(SD= 0.77) to 5.10 (SD= 0.38) for the architects which resulted that most of the respondents know about the green building materials, but with the least mean 2.31 (SD=0.77) for second statement shows that respondents don't know about "LEED" building. The mean ranges from 1.05 (SD= 0.23) to 4.68 (SD= 0.43) for the contractors which resulted that they were not well aware of the GBM, especially about "LEED" building with least mean 1.05 (SD= 0.23). The mean ranges from 1.21 (SD= 0.23) to 2.89 (SD=

1.37) for the building residents who were not well aware of the green building materials.

This concluded that the architects were aware but they must have more information about LEED buildings, which is identifying the level of resource efficiency of a project [7]. The concept along it is also necessary for contractors to have knowledge about green building materials [4] and building residents were at the least level of awareness who need to be guided about green building materials especially natural [2] or to make environment less hazardous and healthier for living [3]. This is also important to increase building life cycle [5,6].

3.2 Efficiency and Cost Estimation of Building Materials (Section 2)

The analysis of the building materials available in Pakistan are discussed here below in relation to their efficiency:

3.2.1 Efficiency of Green Building Materials

3.2.1.1 Green Roof:

A green roof is completely or partially filled with the plant materials either in form of roof gardening or vegetable garden. The rooftop incorporates a waterproof film and some extra layers which include seepage protection layer, water system, root penetration protection etc. The green roof benefits the building in many ways. It is used to lower the heat transfer through roof by adding mass and thus improving its heat resistance value both in Summers and Winters. Green roof can be beneficial for community as well, as it absorbs rainwater, provides insulation and can help in decreasing stress of people around. It also helps to bring aesthetic touch to the architecture [14]. The green roof top is definitely having a higher cost than the usual roof top but it can reduce the cost of electricity and other fuels. A green rooftop is generally 33% more expensive than a normal roof [15]. Such control of sun radiation has been found to reduce temperatures by 20 °C and diminishes the need for any other forms of cooling to 25% from 80%. This abatement in essentialness required to cool a structure in the pre-summer is joined by a lessening in the need to warm a structure in the winter. Therefore, this decreases the need for essentials of the structure all year round which empower the structure temperature to be controlled at a lower cost [16,17].

3.2.1.2 Insulation:

Insulations are characterized as those materials or blends of materials that retard the progression of warmth vitality by performing at least one of the functions. For example, ration vitality by lessening heat misfortune or increase, control surface temperatures for staff assurance and comfort and some more [18]. The heat gain in hot climates can be fairly reduced by well-planned insulation of walls. It can enhance reducing the required heating, ventilation, air conditioning (HVAC) and annual energy cost [19]. The kind of insulation that is present in Pakistan can be used to lower down the energy conservation and is given as follows:

3.2.1.2.1 Gypsum board:

It is a board made of calcium sulfate dehydrates with or without included substances and regularly pressed between two sheets of paper, a facer and a benefactor. It is used to make inside dividers and rooftops. Gypsum board is consistently called drywall, wallboard, or plasterboard. It changes from other board type building things, for instance, compacted wood, hardboard, and fiberboard, in light of its noncombustible focus and paper facers. Whenever joints and latch heads are secured with a joint compound framework, gypsum divider board makes a nonstop surface appropriate [19] for most kinds of inside adornment (Fig. 3).

3.2.1.2.2 Extruded Polystyrene (EPs):

It is a froth item and has turned out to be mainstream in light of its one kind of capacities to extend and its appearance of being 'innovative,' there are different actualities that ought to be considered previously because of its quick consuming and harmful smoke creating attributes in home flames [19].

3.2.1.2.3 Polyurethane (PU):

It is another normal polymer which highlights scraped spot and tear obstruction alongside a large group of alluring attributes. Corrupting minimal after some time or temperature, polyurethane

Table 1. Statements about Awareness Level of Architects, Contractors, and Building Residents

Sr. No	Statements	Respondents					
		Architects		Contractors		Building residents	
		M	SD	M	SD	M	SD
1	I know about "green" building materials.	4.37	0.98	3.26	0.46	2.21	0.55
2	I know about "LEED" building.	2.31	0.77	1.05	0.23	1.21	0.43
3	I am conscious of the building lifetime.	3.26	0.67	3.37	0.68	2.00	0.00
4	I know green buildings cost more than traditional buildings.	3.95	0.42	3	1.03	2.89	1.37
5	I know if a material is green or not.	4.05	0.77	1.68	0.46	2.53	0.51
6	I know where to purchase green building materials.	4.42	0.48	2.42	0.62	2.37	0.48
7	I prefer to use green building materials than conventional materials.	4.42	0.48	2.42	0.62	2.37	0.48
8	I know a recycled material is better than the natural material.	4.58	0.78	2.37	0.50	2.68	0.48
9	I want to minimize the negative impact of building materials on environment.	4.58	0.97	3.58	0.48	2.63	0.97
10	I know we need a future with all green buildings.	5.10	0.38	4.68	0.43	2.74	0.97

is prominent in both business and shopper applications. The low warm conductivity of inflexible polyurethane froth implies that across the board it is used as a protector [19].

3.2.1.3 Low E (Emissivity) Windows:

Emissivity alludes to the nature of the glass surface to reflect heat. The warm emissivity estimation of uncoated glass is 0.91[20] which demonstrate that glass is fundamental wellspring of moving warm vitality in the structure. Low-emissivity glass is a kind of energy efficient glass designed to prevent heat from escaping through your windows to the cold outdoors. Low-E glass is uniquely treated with a minutely slim, for all intents and purposes imperceptible straightforward covering on one surface. The covering reflects warmth back in this way making it appropriate for the houses in hot atmosphere to bring down the warm increase (Fig. 4) [21].

3.2.1.4 Low VOC Paint:

Paint is used for protective layering on wall as well as for decoration, v to indoor air pollution. Paint manufacturers worldwide are now manufacturing low VOC paints to overcome these problems. According to Environmental protection agency of the U.S says that VOC can cause respiratory problems and can be irritating for the consumers. The amount of VOC varies from different paint; paints that are water base have three times less VOC than oil-based paints. Similarly, white or light-colored paints usually have fewer VOC than darker paints; flat paints (paints without sheen) also have low VOC than paints [22]. Willful models for low-VOC, low-dangerous paints have been built up. The non-benefit affirmation association “Green Seal” initially set VOC restrains in 1993 which refreshed in 2010 (Table 2) [23].

3.2.1.5 Cool Brick:

There is a new material being experimented with in Pakistan, propelled by the Muscatese Evaporative cooling window, which joins a fired vessel loaded up with water and a wood screen, the "cool block" was made [24]. A 3D printed porous clay block set in mortar, every block retains water like a wipe and is structured as a three-dimensional cross section that enables air to go through the divider. As air passes

through the 3D printed block. the water that is present in the tiny scale pores of the clay dissipates, bringing cool air into an inside domain, bringing down the temperature utilizing the guideline of evaporative cooling. A ceramic tile based on cool brick (figure 5) ideology is being developed by a student at National College of Arts (NCA) the brick will help to provide thermal comfort within the structure without using any mechanical cooling device, tiles will lower temperature by using evaporative cooling [24].

3.2.1.6 Fly Ash Brick (FAB):

Fly debris block (FAB) is likewise a green structure material, containing fly debris and water. Fly debris blocks for green structure and LEED ventures since they are viewed as a reuse material. Materials and assets utilizing fly debris blocks likewise diminishes the measure of vitality used to deliver customary mud blocks, and the decrease of CO_2 discharges because of the vitality escalated procedure to create those blocks in a 1000-degree C furnace. FAB is replacing the conventional bricks around world. The construction industry of Pakistan can also benefit by using these technologies [25].

The comparison of the efficiency of green and conventional building materials as mentioned above concluded that the green materials are less hazardous and more environment friendly and are the ideal way forward.

3.2.2 Cost Estimation of the Materials

The cost comparison was done on the quotation, provided by Trust Business Solutions (TBS) Pvt Limited [26] in Lahore from the three local markets, namely, Beadon road market, Township market and Ferozepur road market.

Table 3 shows a comparative cost estimation of the green and conventional building materials such as conventional roof costs Rs. 200/m^2 in comparison to green roof which costs Rs. 250 / m^2. A conventional insulated wall with bricks costs Rs.

Table 2. Standard VOC Limits in Wall Paints

Sr. No.	Paint/coating type	VOC concentration limit for basepaint(excluding H2O & tinting added at point of sale)	VOC concentration limit for final mixed paint(including colorant added at point of sale)
1	flat	50g/L	100g/L
2	Non-flat(e.g. gloss, eggshell. Satin, semi-gloss)	100g/L	150g/L
3	Primer or undercoat	100g/L	150g/L
4	Reflective wall	50g/L	100g/L
5	Reflective roof	100g/L	150g/L
6	Floor	100g/L	150g/L

Table 3. Cost Comparison of Green and Conventional Building Materials.

Sr. No.	Materials	Price of Conventional Materials	Price of Green Materials
1	Roofs	Rs. 200 / m2 Conventional Roof	Rs. 425 / m2 Green Roof
2	Insulation	Rs. 250 / m2 Conventional Wall	Rs. 240 to 255 / m2 Insulated Wall
3	Windows	Rs. 460 / m2 Conventional Window (Tilted or Reflective Glass)	Rs. 520 / m2 Low E Window
4	Paints	Rs.230 to 500 / liter Conventional Paints	Rs. 300 to 650 / liter Low VOC Paints

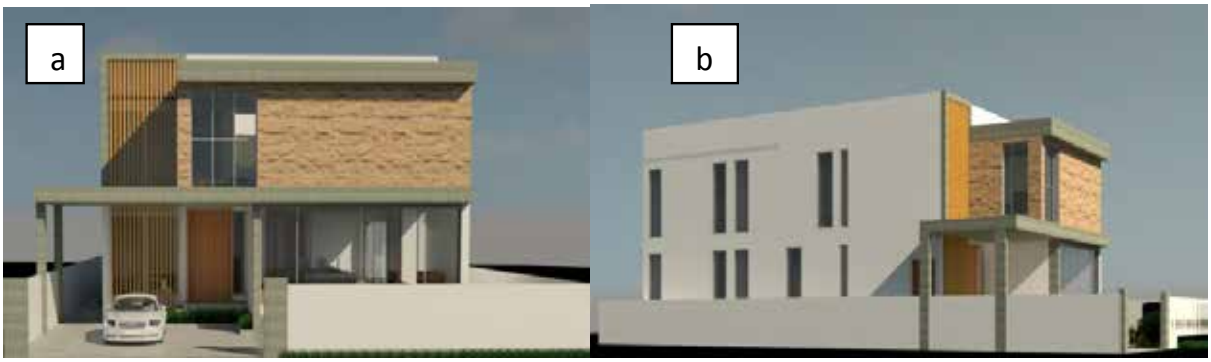

Fig.1a) Front Elevation of the House **1b)** West View of the House

Fig. 2. East view of the house with Green Roof

460/m2 and an insulated wall with gypsum board costs Rs. 240/ m^2 to Rs. 255/m2 he conventional windows with tilted or reflective glass costs Rs. 460 / m^2 l and Low E-window costs Rs. 520 / m^2. The conventional paints cost Rs. 230 to 500 / liter and Low VOC paints cost Rs. 300 to 650 / liter.

It concludes that the green materials cost slightly high [5, 6, 9, 11] for green insulation, windows and paints, but green roof costs almost double than a conventional brick wall. But as above mentioned in the section of efficiency of green building materials the high cost is also giving us a lot of health benefits not only for us but for our next generations so if the future efficiency of energy conservation is measured, the materials do not look costly [9].

3.1 Section 3, Description of a LEED Residential Building

The house was constructed green on demand of the owner. The house is located at DHA phase 5 Lahore and comprises of two floors and a basement. The house is designed by Pakistan Green Building Council (PGBC) and the aim is to introduce green building practices in Pakistan [12]. The proposed house is basic contemporary architecture containing 5 bedrooms (figure 1). The house is example of aesthetic comprises a balcony area with well-planned green patio [14] as well as a green roof which is shown in figure 2 and it is clear that the east view of the house in figure 2 is more attractive [14] than west view of the house in figure 1. The house is able to provide low energy consumption, low thermal gain and less negative impact on surrounding because on the grounds of green roof [4, 5, 7, 6, 11, 15, 16, 17].

4. CONCLUSIONS

The study reveals an effort to highlight the benefits of green building materials, promotion of local markets and to see the awareness level of architects, contractors and building residents about

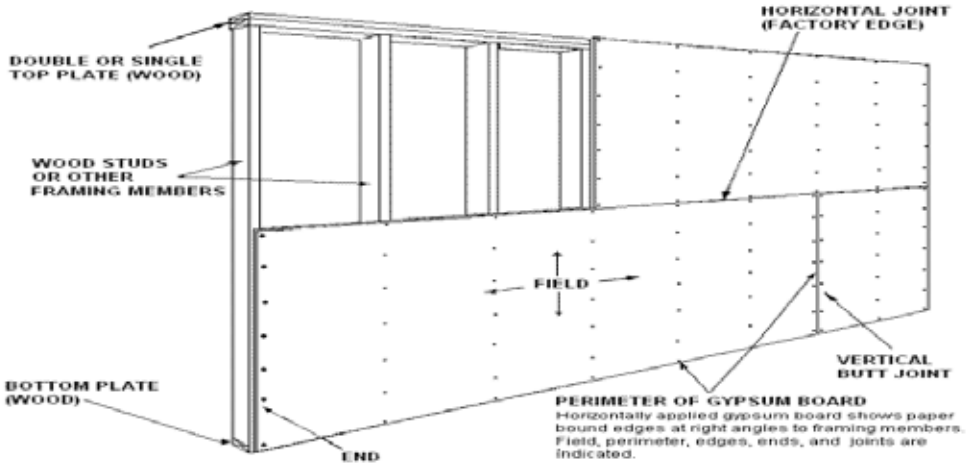

Fig. 3. Horizontally Applied Gypsum Wallboard Showing Joints and Framing

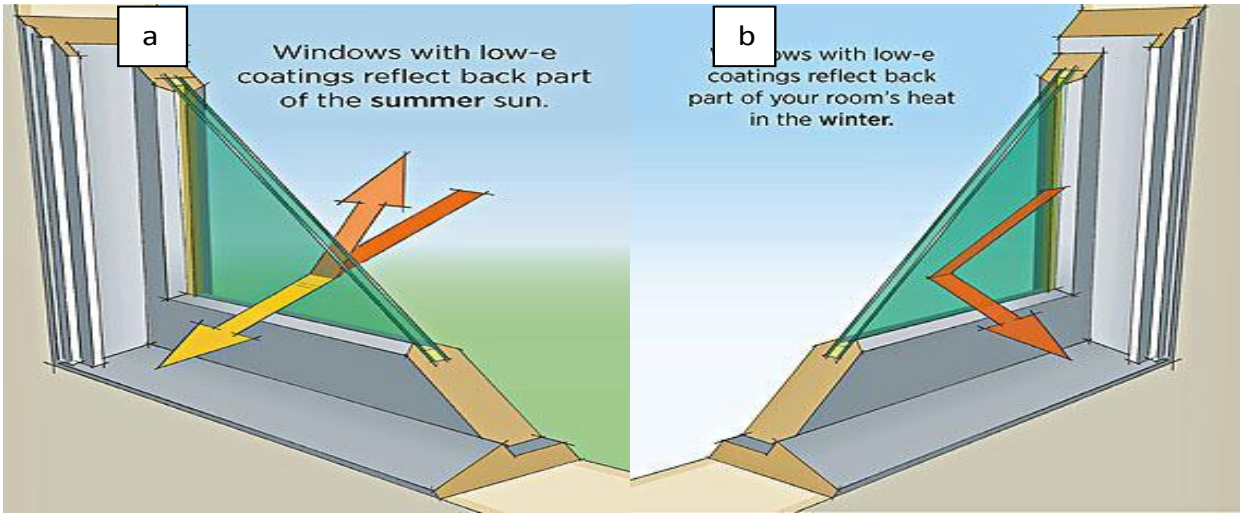

Fig. 4. Low E Windows Reflect Back the Radiation from Sun in Summers 4 b) low E windows can help in heat loss in winters

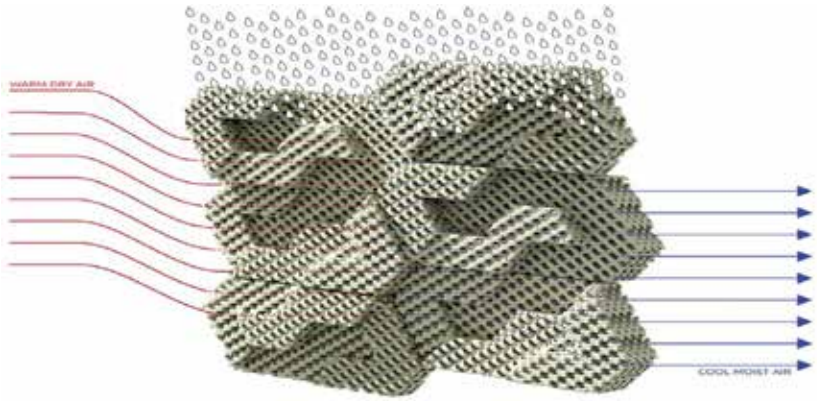

Fig. 5. Inner Structure of Cool Brick
Source: http://www.emergingobjects.com/project/cool-brick/

green building materials. The green materials are proved to be energy efficient, less hazardous and environment-friendly [3]. The efforts are required to make a close connection between architects, builders, engineers, and the clients to make Pakistan at a leading stage in green construction [4]. Everyone must work in lines with United States Green Building Council (USGBC), Leadership in Energy and Environmental Design (LEED), Pakistan Green Building Council (PGBC) and other organizations to gain a high satisfaction level in using green building materials [4, 5, 7, 12]. The results concluded that the architects were aware of green building materials but must be taught about LEED building concepts, contractors and building residents must be guided to increase the use of green building materials. Such as about the green roof functional and aesthetical benefits [14], insulations' types and comfort [18, 19], low E windows' reflection control [21] and low VOC paints' environmental friendliness [22, 23]. Pakistan is lucky that the experiments are being performed on new green building materials like cool brick and fly ash brick [24, 25]. The green materials are less hazardous and more environmentally friendly so the green building materials must be used for survival of next generations even that cost slightly high but as the benefits are the materials not look costly. A house that was analyzed showed that the green roof is not only attractive but the house is also having low energy use, temperature reduction and a positive impact on surroundings.

5. RECOMMENDATIONS

The researcher recommends for the future researchers to further investigate the materials included in the study along with other materials, especially for the floor as a part of interior element in relation to efficiency and cost.

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